



Naval Health Research Center Medical Supply Estimation Process

*Vern Wing
Martin Hill
Jonathan Davis
Carrie Brown*



Naval Health Research Center

Report No. 11-55

The views expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the Department of the Navy, Department of Defense, nor the U.S. Government.

Approved for public release; distribution unlimited.

This research was conducted in compliance with all applicable federal regulations governing the protection of human subjects in research.

*Naval Health Research Center
140 Sylvester Road
San Diego, California 92106-3521*

Naval Health Research Center Medical Supply Estimation Process



Vern Wing
Martin Hill
Jonathan Davis
Carrie Brown

Naval Health Research Center
140 Sylvester Rd
San Diego, California 92106-3521



Report No. 11-55, supported by the Defense Logistics Agency, under Work Unit No. 61042. The views expressed in this article are those of the authors and do not reflect the official policy or position of the Navy, Department of Defense, or the U.S. Government. Approved for public release; distribution is unlimited. This research has been conducted in compliance with all applicable federal regulations governing the protection of human subjects. No human subjects were directly involved in this research.

Background

The U.S. military is committed to providing the highest standard of care for combat casualties. To accomplish this goal, the armed forces have developed highly-mobile medical units capable of bringing advanced medical and surgical care to the forward areas of the battlefield. These units require more modular, flexible, and efficient expeditionary medical configurations to support combat, humanitarian, and peacekeeping missions. To answer this need, the Naval Health Research Center (NHRC) developed a systematic process to analyze, project, and update medical supply requirements for the Marine Corps, Navy, and Air Force. In short, the process identifies the medical tasks required to treat patients with specific injuries and illnesses, and then determines the consumable supplies and equipment required for completing each task.

The NHRC supply review process was first applied to the Marine Corps far-forward, ground-treatment facilities in the mid-1990s. More than 130 subject matter experts with operational experience reviewed treatment briefs, tasks, consumables, and equipment, and examined their usefulness to Marine Corps medical providers.¹⁻⁴

Since then, NHRC's modeling process has been applied to the medical assemblages used by Navy independent duty corpsmen on small ships and general medical officers on amphibious ships, as well as Air Force inventories—such as the Mobile Forward Surgical Team, the Critical Care Air Transport Team, the Special Operations Rapid Response Deployment Kit, and even the Theater Level Expeditionary Medical System. Additionally, the NHRC process was also used in requirements development for new expeditionary medical capabilities such as the Marine Corps' Forward Resuscitative Surgery System, En Route Care System, Short Range Casualty Evacuation System, Corpsman Assault Pack and Combat Lifesaver Pack, and the Fleet's Expeditionary Resuscitative Surgical System. Further, the process has also been used to develop and update medical capabilities for chemical, biological, radiological, nuclear, and enhanced explosive responses, including the Marine Corps' nuclear, biological, and chemical (NBC) first aid kit and NBC unit block, and the Chemical Biological Incident Response Force's medical assemblage. Finally, the process is also used to review and update preventive medicine sets for all three service branches.

Purpose and Objectives

The purposes of this report are to articulate the NHRC supply estimation process using three separate approaches, detail the data requirements for each, and analyze the pros and cons of each method to assist in the development of the Medical Capabilities Requirements Workflow (MCRW) supply estimation process. NHRC has developed a suite of tools and corresponding methodologies to determine the medical supply requirements for a given patient stream. Depending upon both the availability of the data necessary to use them and the ends to be accomplished, one or more may be appropriate for an analysis. This report will enable users to understand the differences in these approaches, and will help inform the decision on which to use to support the MCRW process as it matures. The objectives are outlined below.

Objective 1— Develop a realistic, time-phased patient stream.

Objective 2 —Describe the use of the Enterprise Estimating Supply Program (EESP) and associated methodology to determine the medical supply requirements for Objective 1's patient stream. Describe the pros and cons of using EESP and its methodology.

Objective 3— Describe the use of the ReSupply Validation Program (RSVP) and associated methodology to determine the medical supply requirements for the patient stream. Describe the pros and cons of using RSVP and its methodology.

Objective 4— Describe the use of the Tactical Medical Logistics Planning Tool (TML+) and associated methodology to determine the medical supply requirements for the patient stream. Describe the pros and cons of using TML+ and its methodology.

Methods

NHRC's modeling and simulation suite consists of three modeling programs:

EESP—This program is a deterministic, computer-based, and patient-driven model of clinical operations that enables analysis of medical supply requirements for battlefield operations.

RSVP—This program stochastically generates multiple patient streams to stress a user-defined medical care network to develop combat medical supply estimates based on time-phased resupply “push packages.” RSVP also creates medical contingency files of medical supply items for large-scale operations.

TML+—This application is a discrete-event, stochastic, high-definition planning tool designed to assist medical planners in the development of battlefield medical networks, or to analyze courses of action when developing new medical capabilities.

Each of these capabilities relies on NHRC's Expeditionary Medical Knowledge Warehouse (EMedKW), a database containing more than 180 computer models representing Navy, Marine Corps, and Air Force medical capabilities, including service-specific medical equipment and supplies, clinical tasks, and treatment protocols. Also available in EMedKW are extensive statistical data regarding battlefield-related injuries and diseases as recent as current operations in Iraq and Afghanistan and dating as far back as World War II.

In 2004, NHRC launched a long-term data collection effort tracking patient care for personnel in Iraq and Afghanistan from as far forward as the point of injury through the entire continuum of military medical care, including definitive and rehabilitative care back in the U.S. This massive effort was originally called the Navy-Marine Corps Combat Trauma Registry. However, because the effort has also collected so much non-battle injury (NBI) and illness data, it has evolved into what is now called the Expeditionary Medical Encounter Database (EMED). Statistical analysis of this data is employed in the development of up-to-date patient condition occurrence frequencies (PCOFs), which are used to generate realistic patient streams.

Developing the Patient Stream

Regardless of the method employed, the first step in the supply estimation process is to develop the patient stream(s). There are several ways to do this and the decision usually depends on the particular analysis needed and the data availability.

Historically, casualty estimates have been generated using a range of techniques, including subject matter expert opinions, wargaming, campaign analysis using modeling and simulation, and software specifically designed to produce casualty estimates based on inputs that include population at risk (PAR), battle intensity, environment, and climate.

The most basic casualty stream comprises only numbers of casualties by “casualty type” (e.g., wounded in action [WIA], disease [DIS], and non-battle injury). Refinements in the casualty stream may provide these numbers by day of occurrence and/or time of occurrence. Casualty streams are converted to patient streams by conditioning the numbers of casualties on a PCOF probability distribution. For example, if the casualty estimate specified 10 casualties in a time interval, the patient stream would be constructed by “drawing” on the appropriate PCOF distribution 10 times. The resulting list of 10 *International Classification of Diseases*, 9th Revision (ICD-9) codes would then constitute the patient stream for that time interval. The patient stream contains data on both the numbers of patients and the particular malady from which each patient suffers. The proportion of each type of patient reflects the probability of each malady in the underlying PCOF distribution. Patient streams generated in this fashion do not account for the order that patients would arrive, nor do they account for inter-arrival time. The advantage of generating patient streams this way is that the input data (casualty stream) fidelity is rather low, and therefore, fairly easy to attain.

A more sophisticated approach involves using one of a variety of patient generators. This method requires users to input the force size (PAR), the length of the operation in days or hours, combat intensity, battlefield terrain (desert, mountain, urban, etc.), geographic region, the composition of troops (combat arms, combat support, etc.), and the underlying PCOF distribution, among other data. This process can be accomplished by using stand-alone tools or by being embedded in a larger application. A variety of standalone tools exist to perform this function; the Casualty Estimation (CASEST) model, PATGEN, or NHRC’s Ground Forces Casualty Forecasting System (FORECAS) tool will generate patient streams at various levels of granularity using basically the same input data. Sophisticated simulations like TML+ generate ad hoc patient streams at run time. The advantage of using a patient generator is that it creates the patient stream based on basic parameters that the medical planner should know. Additionally, the number of casualties as a function of time is stochastic vice deterministic, and can therefore provide more realistic patient streams. As before, the proportion of each type of patient reflects each malady’s probability in the underlying PCOF distribution.

After a patient stream has been constructed, it is used as input data to a tool that simulates medical treatment. Here again, there is considerable variance in the fidelity and functionality of the various medical models. The choice of which model to use depends upon the study’s purpose and the input data available.

EESP

At the heart of NHRC's modeling capabilities is a Navy-owned, patented process originally developed for the Estimating Supply Program (ESP).⁵ Initially a stand-alone, computer-based software program, today ESP exists as an easily accessible, online presence known as Enterprise ESP (EESP). Both versions provide deterministic modeling of medical requirements based on patient streams representing various user-defined deployment scenarios (combat, peace keeping, etc.). As previously explained, each patient stream consists of patient condition ICD-9 codes representing battle and non-battle injuries and illnesses seen in the expeditionary environment. In EMedKW, each patient condition is linked to a treatment profile containing the clinical tasks required to treat that condition. Each treatment profile reflects the particular skill levels found at each echelon of expeditionary care, from self/buddy aid to theater hospitalization. Further, each clinical task is mapped to the service-specific equipment and consumables (at the national stock number level of fidelity) required to complete that task for each patient condition at that particular echelon of medical care.

Figure 1 provides an illustration of the NHRC modeling process. Consider ICD-9 800.0 (Closed Fracture of Vault of Skull Without Intracranial Injury) as represented at the Forward Resuscitative Care medical echelon and the functional area (FA) "Triage/Pre-Op." Numerous tasks are associated with this condition, including "Insert Endotrach Tube." The equipment and consumables required to accomplish this task are then identified. Not shown in this illustration are additional data points, including the percentage of patients who get each task, the number of times the task is repeated in a 24-hour period, and the average length of time a patient will remain in the FA. This data structure ties the supply item directly to clinical needs.

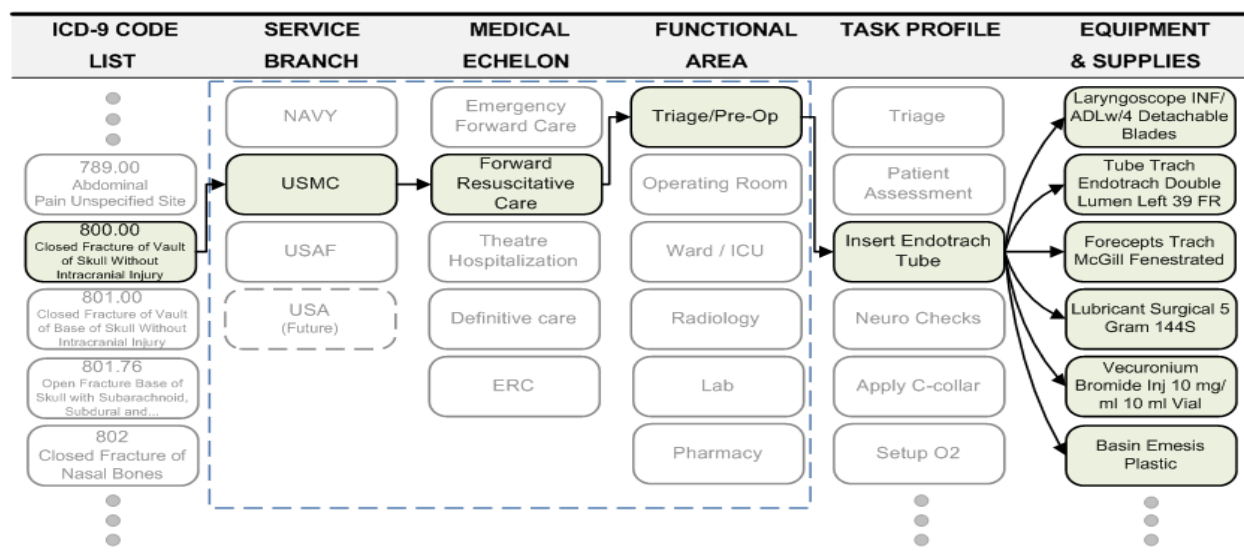


Figure 1. An example of the NHRC modeling process using patient ICD-9 code 800.00.

EESP Inputs

To use EESP, planners either select or copy a pre-loaded scenario or create their own. Scenarios include the medical treatment facilities (MTFs) (e.g., battalion aid station [BAS], field hospital, theater hospital, etc.) and the patient stream. The pre-loaded scenarios represent real-world battles, such as Mogadishu, or scenarios created for war games and exercises, such as Kernel Blitz.

Alternatively, to create a customized scenario, planners may import a patient stream generated by a casualty estimation program such as CASEST, PATGEN or FORECAS. Once the estimator creates a patient stream, it can be imported into EESP as either an Excel file or a delimited text file.

Additionally, planners have two ways of manually building a patient stream inside EESP. They can navigate to the “Build by ICD-9” screen, individually select each ICD-9 patient condition, and input the number of cases for each condition. Alternatively, planners can use the “Build by Injury/Disease” screen to choose injury types and locations, or diseases, and let EESP’s internal PCOF distribution populate the patient stream.

Next, planners choose the treatment capabilities they want in the scenario. They can either choose whole MTFs or individual FAs within MTFs. Table 1 provides a list of all the MTFs currently modeled in EESP. (Note that the FAs within each MTF are not listed.)

Table 1

MTFs Modeled in EESP

- | | |
|--|--|
| - USAF Critical Care Air Transport Team | - USMC Forward Resuscitative Surgery System |
| - USAF EMEDS - HRT | - USMC Self/Buddy Aid |
| - USAF EMEDS +10 | - USMC Surgical Company |
| - USAF EMEDS +25 | - USN CG Independent Duty Corpsman |
| - USAF Global Reach Laydown | - USN DDG Independent Duty Corpsman |
| - USAF In-Flight Medical Kit | - USN Expeditionary Resuscitative Surgery System |
| - USAF Mobile Aeromedical Staging Facility | - USN FFG Independent Duty Corpsman |
| - USAF SOF Casualty Evacuation | - USN General Medical Officer Ships |
| - USAF SOF Rapid Response Deployment Kit | - USN Naval Expeditionary Combat Command |
| - USAF SPEARR | - USN Shipboard Battle Dressing Station |
| - USMC Battalion Aid Station/Sick Call | - USN Shipboard Emergency Response Kit |
| - USMC Casualty Evacuation | - USN Shipboard First Aid Box |
| - USMC Combat Corpsman | - USN Shipboard Jr Emergency Response Kit |
| - USMC Combat Lifesaver | - USN Shipboard Mass Casualty Box |
| - USMC En Route Care | |

EESP Outputs

After running the scenario through EESP, planners can choose a variety of ways to view the results. Table 2 lists EESP's available reports.

Table 2

Reports Available in EESP

Supplies for current scenario	Lists the supplies—including weight, cube, and cost—needed to treat the given patient stream.
Detailed analysis of supplies	Lists the tasks and patient conditions (ICD-9 codes) requiring each supply needed for the patient stream. This is an extremely lengthy report.
Patient stream for current scenario	Lists the number of patients associated with each ICD-9 code in the scenario.
Scenario supplies vs. AMALs	Compares the supplies required for the scenario with those in the authorized medical allowance lists (AMALs). It includes the number of AMALs required to treat the patient stream.
Supplies for selected inventory	Lists the on-hand and on-order quantities of each supply in a selected inventory.
Inventory supplies vs. AMALs	Lists only the supplies in the inventory at variance with authorized allowances (i.e., either less than or greater than the authorized inventory).
Inventory shortage impact	Lists the critical supplies with on-hand quantities less than those authorized in the AMALs.
Scenario supplies vs. inventory	Compares the supplies required by the scenario with those in the inventory.
Scenario impact	Lists the critical supplies in the inventory with on-hand quantities less than those needed to treat a specific patient stream. It includes the ICD-9 codes and tasks affected by the lack of each supply.

Because EESP is deterministic, the same patient stream run through the same MTF/s will generate identical results. By parsing the input scenario into “use cases” where each use case represents a specific level of care comprised only of those MTFs associated with that level of care, the output can produce material item estimates by level of care. Similarly, by parsing the input temporally, output can be generated that corresponds to user-specified time blocks.

EESP Pros

- Requires minimal input data for patient stream, personnel, etc.
- Functions as a fast-running model.
- Generates repeatable results since the model is deterministic.

- Establishes the clinical requirement for each item pushed forward, reducing logistical footprints and enhancing far-forward clinical capabilities.
- Produces an audit trail for each supply.
- Allows optimized supply configurations for changing scenarios or in response to revisions in policy or doctrine, and can be tailored to meet the needs of any operational mission.

EESP Cons

- Does not account for variations in casualty streams because it is deterministic.
- Provides a “point estimate” of supply requirements based on a single patient stream instance.
- Models only the number and types of patients, not their arrival rates/times.
- Does not model equipment availability or use. This can result in understating required repair and maintenance items and preventing analysis of equipment suitability.
- Does not model personnel availability, skill, or use. Assumes necessary personnel are available to perform tasks.
- Does not model a full medical network (e.g., multiple BASs, surgical facilities, etc.) or the logistical elements that move patients within that network.
- Does not model time-phased resupply requirements. As stated above, this can be mitigated by parsing the input data and conducting multiple model runs.

RSVP

Sustaining expeditionary medical operations requires periodic resupply over the length of a deployment. In the past, extra supply blocks were shipped to replenish the original inventory. The initial resupply blocks were basically equivalent to the original supply inventory and were not tied to either anticipated or actual usage. As a result, supply requirements were overstated, causing significant quantities of excess inventory and increasing both the logistical load to move the supplies into theater and the logistical footprint ashore. For example, a 1,000-tablet bottle of aspirin is a BAS AMAL item. Because it is administered for treatment of angina, it is infrequently used in the young, healthy population of a BAS. Therefore, because of its low frequency of use, RSVP would not continually include another bottle in each subsequent BAS re-supply block.

To streamline the resupply process, NHRC created RSVP, a simulation tool that, by running multiple stochastically-generated patient streams, projects the most efficient way to package resupply items in time-phased blocks. Though based on the same NHRC modeling process used in EESP, RSVP also uses a Monte Carlo strategy that applies the PCOF variables to create 100 different patient streams. Additionally, RSVP has the ability to time phase patient arrival and inventory delivery.

RSVP is also used to develop material item estimates called medical contingency files (MCFs). In this process, a scenario, provided by medical planners, is developed based on force size (PAR), casualty estimates, and treatment capabilities (e.g., MTFs). Planners have the option of decrementing the number of casualties in each stream as they move from MTF to MTF, based on the percentage of patients that return to duty, die from their wounds, or skip a level of care.

The model generates a file listing the supplies necessary to treat the patient stream. Since there are 100 randomly generated patient streams, the model provides 100 point estimates of the necessary supplies. These estimates are rank ordered for each supply from lowest to highest use and are tabulated in a single output file. Based on risk tolerance, planners determine which percentile to use for their MCF submissions, though the 75th to the 85th are typically chosen for their robustness. The “mean,” or 50th percentile, should conform to the output of a single run of EESP if the input data are the same.

RSVP Inputs

Like ESP, RSVP was originally designed as a stand-alone computer program but is now incorporated into EMedKW. To begin using RSVP, the medical planner must develop a patient stream using a casualty estimation program like those mentioned above. Just as with EESP, planners import a patient stream and choose the appropriate MTFs or FAs for the scenario. All the MTFs and FAs in EESP are also available in RSVP. As mentioned above, based on empirical results for died of wounds and return to duty rates, planners have the choice of decrementing the number of casualties in each stream as they move from MTF to MTF, or having the entire patient

stream run through each MTF. Planners also set the number of days the operation lasts and which output percentile they want to use in accordance with their risk tolerance.

RSVP Outputs

RSVP simulates consumption by decrementing supply quantities as they are used through multiple iterations of the patient stream. RSVP dynamically tracks the inventory of supplies and reports the quantity of inventory surplus and/or deficiencies, and tracks when they occur in the scenario. RSVP allows planners to look at resupply quantities in a number of different ways: as the unit of measure (UM), or the quantity of each supply to be sent irrespective of packaging; as the UM rounded up to the nearest unit of issue, or the lowest quantity available by package size; and as the UM rounded up to the nearest package, minus the packages left over from previous deliveries. All supplies are identified by national stock number and nomenclature and all national stock numbers are service-specific (i.e., they represent items used by a specific-service MTF). The push packages developed by this process will only include those supplies consumed during each time period, eliminating the wasteful resupply of seldom-used consumables. Figure 2 displays a typical RSVP output for an MCF, showing the quantity of each supply to be sent irrespective of packaging.

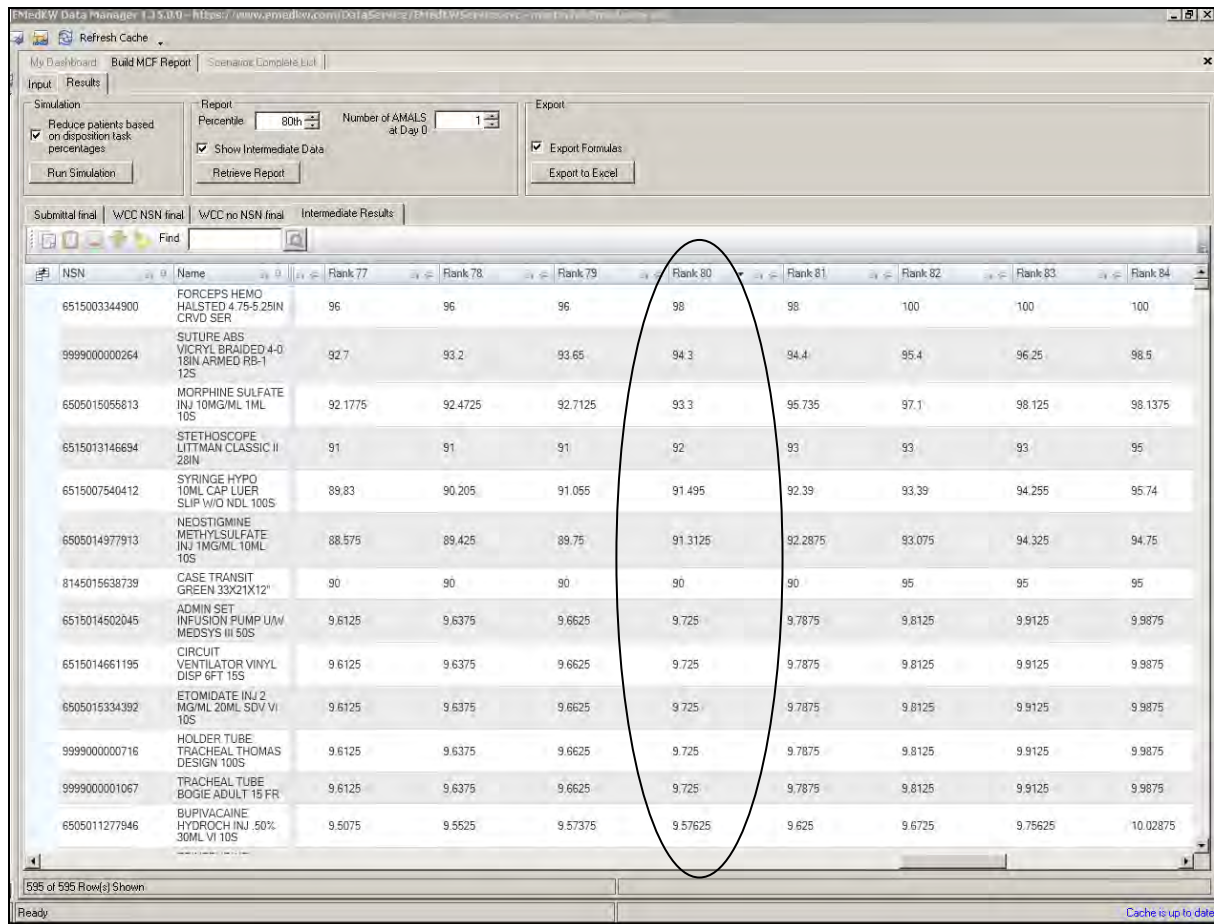


Figure 2. A typical RSVP output for an MCF. This example highlights the re-supply requirements for a risk level at the 80th percentile.

As with EESP, by parsing the input scenario into use cases where each use case represents a specific level of care comprising only those MTF's associated with that level of care, the output can produce material item estimates by level of care. Similarly, by parsing the input temporally, output can be generated that corresponds to user-specified time blocks.

RSVP Pros

- Introduces stochastic variance into the patient stream and thereby provides a more realistic representation of the supply requirements.
- Provides a rank-ordered output that allows the decision maker to choose order quantity as a function of risk tolerance.
- Allows the calculation of confidence intervals and the employment of statistical methods for determining supply requirements' variance, mean, and median.

- Provides the means to reduce the shipment of unnecessary items based on expected patient presentations and supply use.
- Decreases the medical logistics footprint ashore.
- Provides stochastic, time-phased modeling of supply requirements, which permits “just in time” inventory control.
- Reduces the cost of acquiring, storing, and maintaining unnecessary medical assets.
- Decreases on-hand supply quantities for low-frequency use items.
- Decreases inventory holding costs and manpower requirements associated with storing, shipping, maintaining, and inventorying medical supplies.
- Improves medical care when previously undersupplied items are sufficiently supplied.

RSVP Cons

- Models only the number and types of patients, not their arrival rates/times.
- Does not model equipment availability or use. This can result in understating required repair and maintenance items and preventing analysis of equipment suitability (e.g., number of ventilators).
- Does not model personnel availability, skill, or use. Assumes necessary personnel are available to perform tasks.
- Does not model a full medical network (e.g., multiple BASs, surgical facilities, etc.) or the logistical elements that move patients within that network.
- Does not model patient outcomes (mortality, return to duty, etc.) and the concomitant effect on supply use.

TML+

TML+ is a desktop discrete-event simulation that permits operational risk assessments and overall medical systems analysis/operations research studies for a range of military and civilian medical logistics scenarios.

TML+ presents a systems view of the expeditionary MTF network, where the facilities are integrated with transportation assets and compete for medical and logistics resources (staff, equipment, consumables, transporters) as patients flow from the point of injury to definitive care.

The tool produces many dynamic reports that detail medical system effectiveness, mortality, patient disposition, throughput, holding, resource usage, and more.

TML+ uses a graphical user interface (GUI) to easily create baseline scenarios and excursions, execute scenarios, and analyze the results (see Figure 3).

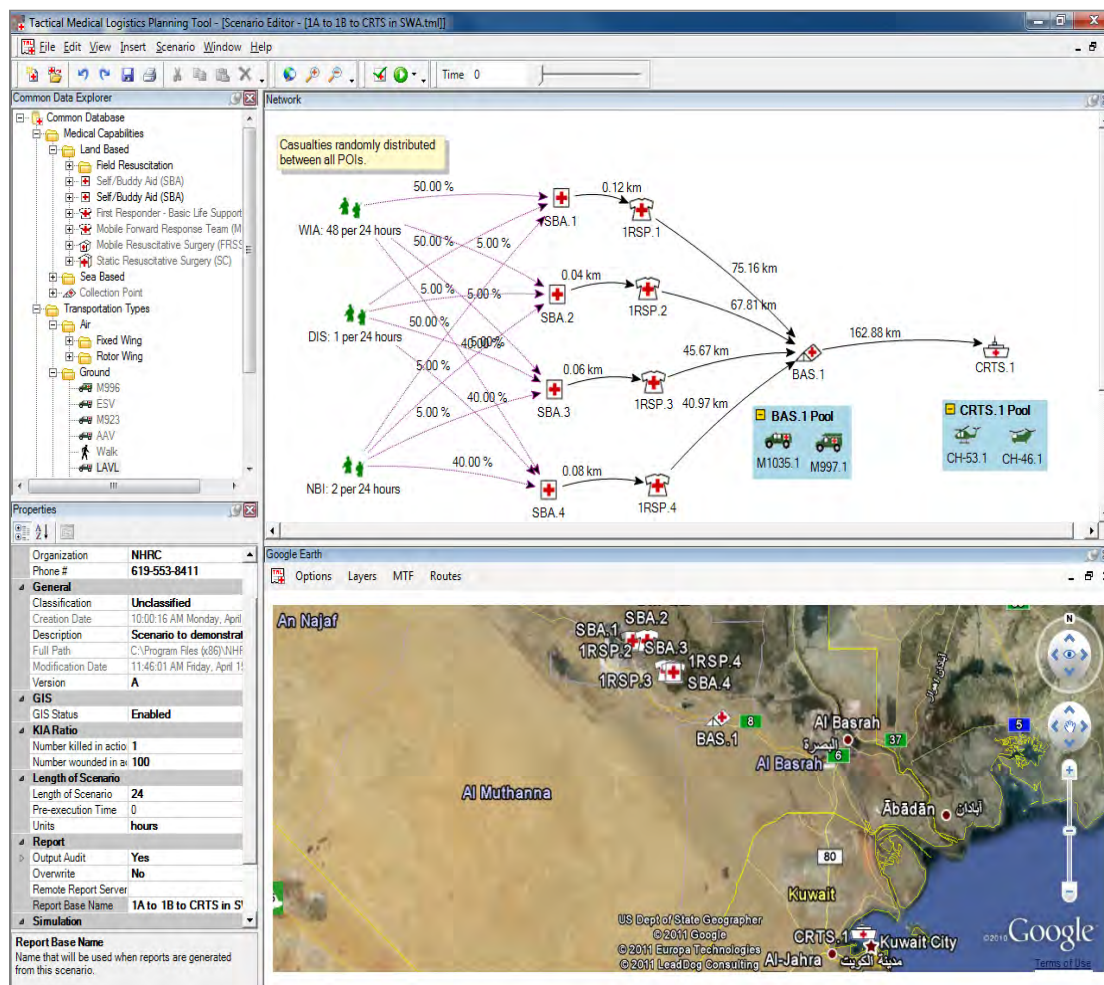


Figure 3. An example of the TML+ GUI.

Unlike EESP and RSVP, it is not necessary to parse the casualty stream because TML+ is a time-stepped, discrete-event simulation. It captures the nuances of the input scenario by giving explicit representation to each MTF at each level of care within the healthcare network. Accordingly, its output can parse supply use at the individual MTF level and/or by level of care on a day-by-day or user-defined time block basis.

There are three steps in using TML+: (1) scenario creation, (2) scenario execution, and (3) results analysis. These steps are briefly described below.

Scenario Creation

TML (like EESP and RSVP) relies on EMedKW for most of its basic input data. MTFs and the FAs they contain, as well as transportation assets and supplies, are instantiated in EMedKW as “objects.” Creating a scenario in TML+ is like building with Lego bricks—analysts construct a scenario from smaller objects stored in EMedKW, to “construct” the medical facilities, transportation assets, casualty streams, etc. that constitute the scenario. Analysts drag and drop the desired medical capabilities onto either a geographical map view or a network view. Analysts then describe the patient movement from one medical facility to another by connecting the facilities visually with a “route link.” All objects in TML+, including MTFs and evacuation assets, are defined in the scenario either by copying and pasting existing assets, by creating new objects from scratch, or by “cloning” an existing object and editing it to have the desired characteristics. Evacuation assets may be placed on the map view or network view by dragging and dropping. Casualty streams generated from tools as described above can be input directly or TML+ can generate them at run time based on user input PCOF distributions. TML+ uses the MTF, transportation asset, medical treatment tasks, and supply data to treat the patient stream.

Scenario Execution

Analysts may “run” a single scenario or several scenarios in batch mode. The run’s progress is displayed, and analysts may abort it at any time. In addition, TML+ contains a “convenience” feature to quickly increase or decrease the number of casualties flowing through a scenario’s medical network.

Results Analysis

In addition to resource usage, which provides the capability to produce a material item estimate, TML+ has a robust report generator. Output can be generated that describes medical system effectiveness, mortality, patient disposition, throughput, holding, and more. Reports may be displayed in a variety of formats, including tabular, charts and graphs, distribution and percentile, and time series. Tabular data may be filtered, sorted, and exported to Microsoft Excel. Additionally, analysts may define their own report and save it as a “favorite” for later use.

TML+ Inputs

TML+ inputs include the following:

- Capabilities of care
- FAs
- Personnel
- Personnel skill sets
- Patient treatment profiles including tasks, times, sequences, responsible personnel, and supplies needed
- Supplies
- PCOF distributions
- Weight, volume, and cost
- Died of wounds due to delay
- Type, speed, and capacity of transportation assets

TML+ makes use of the following databases and predictive tools:

EMedKW relational database—EMedKW is a service-oriented architecture system designed to protect and organize the medical data that NHRC uses in conjunction with TML+ and other analytic tools. All TML+'s underlying data is stored in EMedKW.

EMED—The EMED currently captures casualty treatment information from the point of injury through definitive care to evaluate our deployed medical system effectiveness. These data are used to determine injuries and illnesses and estimate WIA, DIS, and NBI rates. These rates and distributions of patient types serve as input to TML+.

FORECAS tool—FORECAS uses statistical estimations based on data from previous actual combat scenarios to project numbers of WIA, killed in action, DIS, and NBI for a given situation. TML+ uses FORECAS to produce casualty estimates for its scenarios when these casualty estimates are not provided by some other means (e.g., user defined).

CASEST model—CASEST was developed by the Marine Corps to predict casualties and injury distribution by grade and military occupation specialty and patient condition code. The Marine Corps has decided to abandon CASEST, but TML+ retains the capability to import CASEST casualty data.

TML+ Outputs

TML+ produces a large set of dynamic reports that detail medical system effectiveness, mortality, patient disposition, throughput, holding, resource utilization, and much more. Table 3 lists a few of TML+'s available reports.

Table 3

A Sample of Reports Available in TML+

Casualty metrics	Number, arrival time, disposition, type, group, category, mortality risk, and throughput.
Care providing metrics	Number treated, number returned to duty, number evacuated, number died of wounds, length of stay, wait time, time to surgery, tasks performed, tasks delayed, personnel utilization.
Class VIII utilization metrics	Equipment utilization, consumables used, and supply used by weight, volume, and cost by MTF or band of care.
Transportation metrics	Number of trips, patients transported per trip, asset utilization, trip duration, wait time.

TML+ Pros

- Models not only the number and types of patients, but their arrival rates and times as well. Gives time-phased patient streams at the resolution of 1-minute intervals.
- Models patient encounters and admissions.
- Develops ad hoc patient streams based on user input PCOFs and rates.
- Models equipment availability and use. Thus capturing required repair and maintenance items and enabling analysis of equipment suitability (e.g., number of ventilators).
- Models personnel availability, skill, and use. Allows substantiation of personnel down to a minimum capability level. Halts patient flow if necessary personnel are not available to perform tasks.
- Models the full medical network (e.g., multiple BASs, surgical facilities, etc.) and the logistical elements that move patients within that network.
- Uses Monte Carlo strategies and is stochastic, which gives TML+ the ability to run multiple replications.
- Provides time-phased implementation of the network of medical care that can be synchronized with the operational plan
- Can be used in either constrained or unconstrained mode. This enables the analyst to either interrupt a simulation run when a given supply runs out or to simply log the occurrence.

- Models mortality due to delay in treatment with an algorithm derived from subject matter expert inputs and EMED clinical encounter data.
- Allows the user to easily create scenarios, play “what-if” games, and analyze the results by using TML+'s GUI.
- Provides a powerful, flexible, and easy-to-use reporting tool that aids searching and organizing the myriad of output data.
- Allows the creation of tailored reports through its robust reporting functionality
- Tracks supply usage by individual MTF and/or level of care at the 1-minute increment level of fidelity.

TML+ Cons

- Data intensive. Requires substantial network and planning data to use the full range of capabilities
- Does not model resupply of consumables. Currently tracks when consumables are depleted.
- Does not track the movement of Enroute Care System staff who board evacuation assets to treat patients and must eventually return to the originating facility.
- Does not model attrition of medical staff due to many factors, including injury.

Summary

In summary, data requirements vary for each tool and methodology. For example, TML+ requires CONOPS information for a specific mission, while EESP does not. Availability of input data at the required level of granularity will dictate whether or not a given tool can be used.

As currently configured, each of the three tools can be used to produce a material item list keyed to a COCOM-generated scenario. If the input data are restricted to casualty streams and numbers and types of MTFs, either EESP or RSVP is probably the most appropriate tool, but TML+ can also be operated in a degraded mode to develop the material item estimate. The accuracy of the material item estimate is tied directly to the quality of the input data. Restricting data to the basics of a casualty stream—as a function of type and day and healthcare network to numbers and types—will always produce results that are questionable. Investment in acquiring more accurate and descriptive input data through collaboration with the COCOM customer will enable a valid proof-of-concept demonstration. Lack of that investment will reduce the proof of concept to an exercise in identifying gaps in the process rather than refining it.

References

1. Galarneau, M. R., Mahoney, K. J., Konoske, P. J., & Emens-Hesslink, K. E. (1997). *Development of a model for predicting medical supply requirements at the forward echelons of care: Preliminary findings for Echelon II laboratory and x-ray ancillaries* (NHRC Tech. Rep. No. 97-3). San Diego, CA: Naval Health Research Center.
2. Galarneau, M. R., Konoske, P. J., Emens-Hesslink, K. E., Pang, G., & Gauker, E. (1997). *Model for predicting medical supply requirements at the forward echelons of care: Findings for the Battalion Aid Station* (NHRC Tech. Rep. No. 97-28). San Diego, CA: Naval Health Research Center.
3. Galarneau, M. R., Konoske, P. J., Emens-Hesslink, K. E., & Pang, G. (1998). *Reducing the logistical footprint of Forward Resuscitative Surgical Units using a patient-driven model of clinical events* (NHRC Tech. Rep. No. 98-1). San Diego, CA: Naval Health Research Center.
4. Galarneau, M. R., Pang, G., Konoske, P. J., & Gauker, E. (1998). *Using a model of clinical events to determine supply requirements for Marine Corps Shock Surgical Team/Triage (SST) and Acute Care Ward Units* (NHRC Tech. Rep. No. 98-15). San Diego, CA: Naval Health Research Center.
5. Konoske, P. K., Galarneau, M. R., Pang, G., & Daly, T. (2010). *U.S. Patent No. 7,707,042*. Washington, DC: U.S. Patent and Trademark Office.

REPORT DOCUMENTATION PAGE

The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB Control number. **PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.**

1. REPORT DATE (DD MM YY) 12 09 11		2. REPORT TYPE Technical Report		3. DATES COVERED (from – to) June–July 2011	
4. TITLE Naval Health Research Center Medical Supply Estimation Process				5a. Contract Number: 5b. Grant Number: 5c. Program Element Number: 5d. Project Number: 5e. Task Number: 5f. Work Unit Number: 61042	
6. AUTHORS Wing, Vern; Hill, Martin; Davis, Jonathan; Brown, Carrie				8. PERFORMING ORGANIZATION REPORT NUMBER Report No. 11-55	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Commanding Officer Naval Health Research Center 140 Sylvester Rd San Diego, CA 92106-3521					
8. SPONSORING/MONITORING AGENCY NAMES(S) AND ADDRESS(ES) Commanding Officer Naval Medical Research Center 503 Robert Grant Ave Silver Spring, MD 20910-7500				10. SPONSOR/MONITOR'S ACRONYM(S) NMRC/BUMED	
Chief, Bureau of Medicine and Surgery (MED 00), Navy Dept 2300 E Street NW Washington, DC 20372-5300				11. SPONSOR/MONITOR'S REPORT NUMBER(s)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT The purpose of this report is to articulate the Naval Health Research Center supply estimation process using three separate approaches, detail the data requirements for each, and analyze the pros and cons of each method to assist in the development of the Medical Capabilities Requirements Workflow supply estimation process. NHRC's modeling and simulation suite consists of three modeling programs: the Enterprise Estimating Supplies Program, the ReSupply Validation Program, and the Tactical Medical Logistics Planning Tool. As currently configured, each of the three tools can be used to produce a material item list keyed to a scenario. The accuracy of the material item estimate is tied directly to the quality of the input data.					
15. SUBJECT TERMS requirements estimation, EESP, TML+, Enterprise Estimating Supplies Program, Tactical Medical Logistics Planning Tool, EMedKW, RSVP, ReSupply Validation Program					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UNCL	18. NUMBER OF PAGES 20	18a. NAME OF RESPONSIBLE PERSON Commanding Officer
a. REPORT UNCL	b. ABSTRACT UNCL	c. THIS PAGE UNCL			18b. TELEPHONE NUMBER (INCLUDING AREA CODE) COMM/DSN: (619) 553-8429

REPORT DOCUMENTATION PAGE

The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB Control number. **PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.**

1. REPORT DATE (DD MM YY) 12 09 11			2. REPORT TYPE Technical Report		3. DATES COVERED (from – to) June–July 2011	
4. TITLE Naval Health Research Center Medical Supply Estimation Process					5a. Contract Number: 5b. Grant Number: 5c. Program Element Number: 5d. Project Number: 5e. Task Number: 5f. Work Unit Number: 61042	
6. AUTHORS Wing, Vern; Hill, Martin; Davis, Jonathan; Brown, Carrie					8. PERFORMING ORGANIZATION REPORT NUMBER Report No. 11-55	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Commanding Officer Naval Health Research Center 140 Sylvester Rd San Diego, CA 92106-3521						
8. SPONSORING/MONITORING AGENCY NAMES(S) AND ADDRESS(ES) Commanding Officer Naval Medical Research Center 503 Robert Grant Ave Silver Spring, MD 20910-7500					10. SPONSOR/MONITOR'S ACRONYM(S) NMRC/BUMED	
Chief, Bureau of Medicine and Surgery (MED 00), Navy Dept 2300 E Street NW Washington, DC 20372-5300					11. SPONSOR/MONITOR'S REPORT NUMBER(s)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.						
13. SUPPLEMENTARY NOTES						
14. ABSTRACT The purpose of this report is to articulate the Naval Health Research Center supply estimation process using three separate approaches, detail the data requirements for each, and analyze the pros and cons of each method to assist in the development of the Medical Capabilities Requirements Workflow supply estimation process. NHRC's modeling and simulation suite consists of three modeling programs: the Enterprise Estimating Supplies Program, the ReSupply Validation Program, and the Tactical Medical Logistics Planning Tool. As currently configured, each of the three tools can be used to produce a material item list keyed to a scenario. The accuracy of the material item estimate is tied directly to the quality of the input data.						
15. SUBJECT TERMS requirements estimation, EESP, TML+, Enterprise Estimating Supplies Program, Tactical Medical Logistics Planning Tool, EMedKW, RSVP, ReSupply Validation Program						
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UNCL	18. NUMBER OF PAGES 20	18a. NAME OF RESPONSIBLE PERSON Commanding Officer	
a. REPORT UNCL	b. ABSTRACT UNCL	c. THIS PAGE UNCL			18b. TELEPHONE NUMBER (INCLUDING AREA CODE) COMM/DSN: (619) 553-8429	